PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 :
H04Q 9/00, H04N 7/18, G06T 15/10

A1

(11) International Publication Number: WO 00/08889

(43) International Publication Date: 17 February 2000 (17.02.00)

(21) International Application Number: PCT/US99/01104

(22) International Filing Date: 19 January 1999 (19.01.99)

(30) Priority Data:
09/131,186 7 August 1998 (07.08.98) US

(71) Applicant (*for all designated States except US*): BE HERE, INC. [US/US]; Suite 100, 20195 Stevens Creek Boulevard, Cupertino, CA 95014 (US).

(72) Inventors; and
(75) Inventors/Applicants (*for US only*): FURLANI, John [US/US]; 749 Webster Street, Palo Alto, CA 94301 (US). DRISCOLL, Edward, Jr. [US/US]; 11 Sandstone, Portola Valley, CA 94028 (US).

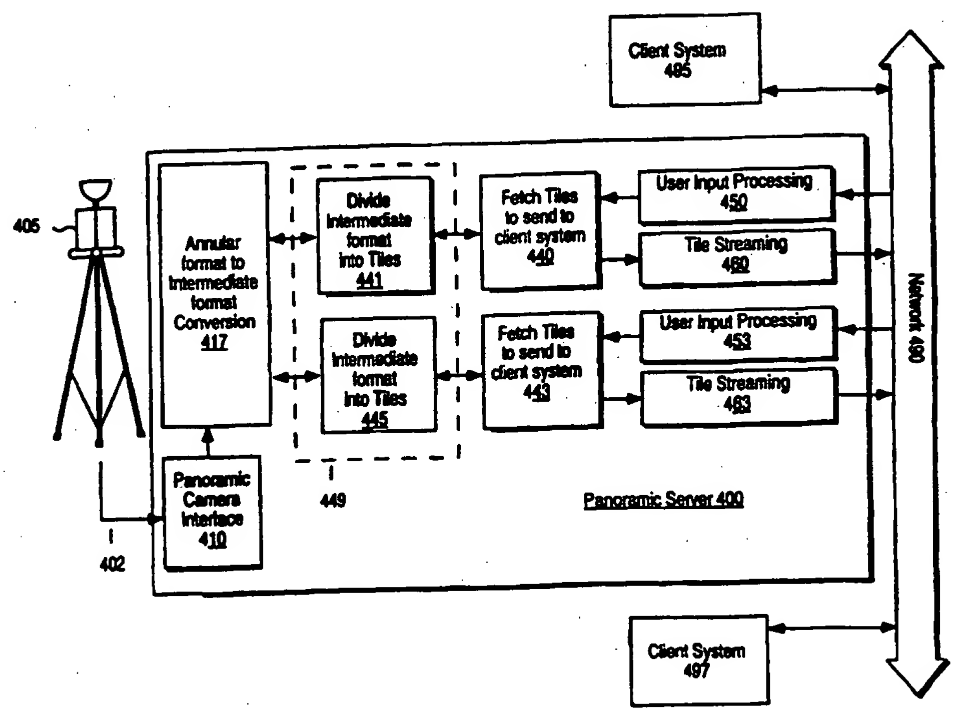
(74) Agents: JOHANSEN, Dag, J. et al.; Blakely, Sokoloff, Taylor & Zafman LLP, 7th floor, 12400 Wilshire Boulevard, Los Angeles, CA 90025 (US).

(81) Designated States: AL, AM, AT, AT (Utility model), AU (Petty patent), AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, CZ (Utility model), DE, DE (Utility model), DK, DK (Utility model), EE, EE (Utility model), ES, FI, FI (Utility model), GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SK (Utility model), SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published
With international search report.

(54) Title: METHOD AND APPARATUS FOR ELECTRONICALLY DISTRIBUTING MOTION PANORAMIC IMAGES

(57) Abstract



The present invention discloses an electronic image distribution apparatus for distributing motion panoramic images. The main portion of the apparatus is a motion panoramic image server that has a source of motion panoramic images. The source of the panoramic images frames may be a motion panoramic image playback device or a motion panoramic camera system (405). The motion panoramic image server (400) transforms the panoramic image frames into an intermediate format that is more conducive for electronic transmission (417). The motion panoramic image server (400) then transmits the motion panoramic images to client systems (495, 497). A first transmission system divides the intermediate planar representation into individual tiles (441, 445) and transmits tiles that are requested by clients systems (440, 443). A second panoramic image transmission system divides the intermediate planar representation into individual tiles on different multicast channels. Client systems (495, 497) then subscribe to the multicast channels needed to render an image in the direction of a desired view.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece			TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	NZ	New Zealand		
CM	Cameroon			PL	Poland		
CN	China	KR	Republic of Korea	PT	Portugal		
CU	Cuba	KZ	Kazakstan	RO	Romania		
CZ	Czech Republic	LC	Saint Lucia	RU	Russian Federation		
DE	Germany	LI	Liechtenstein	SD	Sudan		
DK	Denmark	LK	Sri Lanka	SE	Sweden		
EE	Estonia	LR	Liberia	SG	Singapore		

Method and Apparatus For Electronically Distributing Motion Panoramic Images

FIELD OF THE INVENTION

The present invention relates to the field of image processing and data distribution. In particular the present invention discloses methods and apparatus for processing, transmitting, and post-processing panoramic image information.

BACKGROUND OF THE INVENTION

Most cameras only record a view within a small viewing angle. Thus, a typical conventional camera only captures an image in the direction that the camera is aimed. Such conventional cameras force viewers to look only at what the camera operator chooses to focus on.

Panoramic cameras capture a much wider field of field. A panoramic camera constructed using an optical "fish-eye" lens may capture at most a 210 degree field of view. A panoramic camera constructed with a catadioptric lens captures a full 360 degree panoramic image. With a large panoramic field of view, individual panoramic image viewers can decide what they will focus on.

Conventional images are often delivered by electronic means. For example, television and the Internet deliver conventional images across wired and wireless electronic media. However, there are no standard means of delivering panoramic images electronically. Since panoramic images are so large, it is difficult to deliver panoramic images using conventional image transmission techniques. To further compound the problem, motion panoramic images require a very high bandwidth channel for electronic distribution. Thus, it would be desirable to have an electronic distribution system that efficiently distributes motion panoramic image information.

SUMMARY OF THE INVENTION

The present invention discloses an electronic image distribution apparatus for distributing motion panoramic images. The main portion of the apparatus is a motion panoramic image server that has a source of motion panoramic images. The source of panoramic image frames may be a motion panoramic image playback device or a connection to a motion panoramic camera system. The motion panoramic image server transforms the panoramic image frames into an intermediate planar representation that is more conducive for electronic transmission. The motion panoramic image server then transmits the motion panoramic images to client systems. The present invention proposes two different transmission systems.

A first panoramic image transmission system divides the intermediate planar representation into individual tiles. Individual client systems then request the individual tiles needed to construct a view into the panoramic image on the client system. The server then transmits the requested tiles to the client system. A highly compressed full panoramic image is transmitted occasionally to handle a situation where a user has moved the view into the panoramic image to a position where the client system does not have the necessary tiles for creating a view.

A second panoramic image transmission system also divides the intermediate planar representation into individual tiles. However, the second panoramic image transmission system then transmits the individual tiles on different multicast channels. Client systems then subscribe the multicast channels needed to render an image in the direction of a desired view.

Other objects, features and advantages of present invention will be apparent from the company drawings and from the following detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

The objects, features and advantages of the present invention will be apparent to one skilled in the art, in view of the following detailed description in which:

Figure 1 illustrates one embodiment of a panoramic camera system that creates annular images.

Figure 2a illustrates an annular image that is recorded by the panoramic camera system of **Figure 1**.

Figure 2b illustrates how the annular image of **Figure 2a** appears after it has been unwrapped by geometrical transformation software.

Figure 3 illustrates the 360 degree band that the panoramic camera system of **Figure 1** captures and **Figure 3** also illustrates a cylindrical projection data format.

Figure 4 illustrates a networked computer systems arrangement used to distribute motion panoramic images captured by the panoramic camera system **Figure 1** from a panoramic image server to client systems.

Figure 5A illustrates a conceptual view of a spherical view captured by the panoramic camera system of **Figure 1**.

Figure 5B illustrates a panoramic image frame in a spherical intermediate planar representation that has been unwrapped and divided into individual tiles.

Figure 5C illustrates a panoramic image frame in a cylindrical intermediate planar representation that has been divided into individual tiles or a spherical intermediate planar representation that has been adjusted and divided into tiles.

Figure 5D illustrates a panoramic image frame in a low resolution intermediate planar representation that has been divided into individual tiles.

Figure 5E illustrates a panoramic image frame in a medium resolution intermediate planar representation that has been divided into individual tiles.

Figure 5F illustrates a panoramic image frame in a high resolution intermediate planar representation that has been divided into individual tiles.

Figure 5G illustrates a panoramic annular image frame that has been divided into spatially variant tiles.

Figure 6A illustrates a view within a panoramic image frame in an intermediate planar representation.

Figure 6B illustrates four tiles from **Figure 6A** transmitted to construct a view within a client system.

Figure 7A illustrates a view within a panoramic image frame intermediate planar representation that has suddenly shifted by a large angular value.

Figure 7B illustrates a view within a panoramic image frame intermediate planar representation that has suddenly shifted by a small angular value.

Figure 8 illustrates a flow diagram that describes how a panoramic image client system negotiates a connection with a motion panoramic image server.

Figure 9 illustrates a flow diagram that describes how a motion panoramic image server sends image tiles to a panoramic image client.

Figure 10 illustrates a flow diagram that describes how a motion panoramic image client renders a panoramic image view using image tiles received from a server.

Figure 11 illustrates a panoramic image frame in an intermediate planar representation that has been divided into overlapping tiles.

Figure 12 illustrates a networked computer arrangement wherein a panoramic image server distributes motion panoramic image tiles on individual multicast channels.

Figure 13 illustrates a flow diagram that describes how a motion panoramic image client subscribes to multicast panoramic image tile channels and renders an image using received image tiles.

Figure 14 illustrates a panoramic annular image divided into quadrants that are served on different multicast channels.

Figure 15 illustrates a panoramic image server that transmits panoramic image information on different multicast channels on a multicast backbone and client systems that subscribe to the multicast channels.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

A method and apparatus for compressing and distributing motion panoramic images is disclosed. In the following description, for purposes of explanation, specific nomenclature is set forth to provide a thorough understanding of the present invention. However, it will be apparent to one skilled in the art that these specific details are not required in order to practice the present invention. For example, the present invention's method of distributing panoramic images has been described with reference to the Internet. However, other types of digital information distribution systems such as private data networks and satellite systems may be used with the teachings of the present invention.

The Basic Panoramic Camera Design

Figure 1 illustrates an embodiment of one possible 360 degree panoramic camera system. The image capture mechanism **150** of the panoramic camera system captures an angular image of the surrounding panorama that is reflected off the main reflector **110**. More details about the panoramic camera system of **Figure 1** can be found in the copending patent application entitled "Panoramic Camera", filed June 11, 1997 and having serial number 08/872,525 which is hereby incorporated by reference.

Figure 2a illustrates an example of a panoramic image captured as an annular image. As illustrated in **Figure 2a**, the surrounding panorama is distorted by the main reflector having radial symmetry such that the surrounding represented as a two-dimensional annular image. In one embodiment, the shape of the main reflector transforms the standard rectangular coordinate system of the image into a polar coordinate system. To view the panoramic image captured as a two-dimensional annular image, the annular image may be unwrapped to create an intermediate planar representation. The unwrapping is performed using a geometric transformation operation. **Figure 2b** illustrates how the annular image of **Figure 2b** appears after the images are geometrically transformed from the annular representation to a rectangular intermediate planar representation.

The panoramic camera system of **Figure 1** captures an entire 360 degree image of the surrounding horizon as illustrated in **Figure 3**. The panoramic camera system captures a panoramic image that includes objects as low as 50 degrees below the horizon and objects as high as 50 degrees above the horizon. However, alternate panoramic camera systems may capture a full spherical panoramic view, a partial 180 degree hemispherical view, or any other panoramic view. Furthermore, a panoramic image may be constructed by combining a mosaic of convention images captured with convention camera systems. For example, eight convention cameras can be used to capture images from eight different directions. Those images are then combined together to create a single panoramic image.

A Motion Panoramic Image Capture System

When the image capture mechanism **150** of the panoramic camera of **Figure 1** is a motion image capture mechanism such as a charged coupled device (CCD) or a film-based motion picture image capture system, then it is possible to capture a series of panoramic annular images. The series of panoramic annular images can be used to generate a motion panoramic display. **Figure 4** illustrates one possible embodiment of an electronic motion panoramic image capture system.

Referring to **Figure 4**, a panoramic camera system **405** captures a series of panoramic annular image frames with an electronic image capture mechanism. For example, the electronic image capture mechanism can be a charged coupled device image capture mechanism or CMOS image sensor that generates digitized panoramic annular image frames. The panoramic annular image frames are transmitted from panoramic camera system **405** to a panoramic image server **400** across a high bandwidth communication link **402**. The communication link must be high bandwidth since each panoramic annular image frame contains a very large amount of information and to provide a flicker-free motion image, several panoramic images must be transmitted each second.

Alternate embodiments of motion panoramic image capture systems can also be used. For example, a motion panoramic capture system may be created with two motion

picture camera systems pointing in opposite directions wherein each motion picture camera system is equipped with a fisheye lens that captures at least a 180 degree hemispherical field of view. In such a panoramic image system, two distorted fisheye images from each hemispherical view would need to be "stitched" together in to created a single panoramic image.

A First Motion Panoramic Image Distribution System Embodiment

As previously set forth, the full panoramic annular image frames generated by the panoramic camera system (such as panoramic camera system **405** of **Figure 4**) are so large that a very high bandwidth link is needed to transmit full motion images to a recipient. Such high bandwidth links are rare and expensive. Thus, for mass distribution of panoramic imagery, more bandwidth efficient methods of distributing panoramic images are needed.

The present invention introduces two different methods of distributing motion panoramic images. A first method divides panoramic images into tiles and transmits only the tiles needed to construct a desired image. A second method, described in a later section, divides panoramic images into individual tiles and then transmits all the tiles on different multicast channels.

<u>The Selective Tile Transmission System</u>

To efficiently transmit a panoramic image, the present invention first proposes a selective tile transmission system. In the selective tile transmission system, a server computer system divides each panoramic frame into tiles. The tile size and shape are preferably selected in such a manner that is dependent upon a coordinate system used by the format used to transmit the tiles. Then, the tiles needed to construct an image on a client computer system are transmitted from the server system to individual clients.

In a preferred embodiment, the server system transforms each incoming panoramic image frame into an intermediate planar representation. This transformation step is not necessary but provides certain advantages. The selective tile transmission system will

be described with reference to a system that performs this transformation in **Figures 4, 5, 6, 7, 8** and **9**.

Referring to the particular embodiment of the selective transmission system illustrated in **Figure 4**, a panoramic annular image transformation system **417** "unwraps" annular panoramic image frames into an intermediate planar representation. The intermediate planar representation is more convenient for generating images suitable for viewing. Specifically, the intermediate format should require fewer calculations to generate a final rectangular projection.

In one embodiment, the incoming annular panoramic image data is geometrically transformed into a spherical coordinate system with a spherical projection representation. In such an embodiment, a single frame of the image data may be viewed with the Live Picture viewer from Live Picture, Inc. **Figure 5A** conceptually illustrates a spherical data format wherein the view of the surroundings is projected onto a sphere surrounding a view point.

In another embodiment, the incoming annular panoramic image data is geometrically transformed into a cylindrical coordinate system in a cylindrical projection representation. An image transformed into a cylindrical coordinate system may be viewed with the QuickTime VR viewer created by Apple Computer, Inc. **Figure 3** conceptually illustrates a cylindrical data format wherein the view of the surroundings is projected onto a cylinder surrounding a view point.

After converting the panoramic image frames into an intermediate planar representation, the system of the present invention divides the intermediate planar representation into individual tiles. In the present invention, the size of the tiles are dependent upon the coordinate system of the intermediate planar representation. In such embodiments, the tiles may be spatially variant.

The size of the tiles may further be dependent upon the client system that will be displaying the panoramic image data. In such an embodiment, each client uses a different process (**441** or **445**) to divide intermediate planar representations into tiles since each client may use different client sizes. However, in a standardized embodiment, the size of the tiles are fixed such that a single process (illustrated as dotted box **449**) may be used to divide an intermediate planar representation into individual tiles.

Figure 5A illustrates a conceptual diagram of the spherically encoded intermediate planar representation. As illustrated in **Figure 5A**, the spherically encoded intermediate planar representation represents the surrounding world as image data mapped onto a sphere. To divide and organize the data, the sphere is broken into individual bands on sphere A, B, C, D, E, and F. Note that the bands near the "equator" of the spherically encoded intermediate planar representation contain more data than the bands closer to the "poles."

In one embodiment of the present invention, the image data is represented individual bands that are divided into individual tiles as illustrated in **Figure 5B**. Note that there will be fewer tiles in the bands from higher inclination angles. Alternatively, there will be the same number of tiles, but the tiles will contain data from a smaller yaw angles. If the data from the smaller yaw angles is increased, this type of intermediate data format can be graphically illustrated as show in **Figure 5C**. Note that the graphical data representation of **Figure 5C** also matches the cylindrical data format of **Figure 3**. Although the data format of **Figure 5B** may be used and provides certain advantages such as a more compact data format, this document will focus on the format of **Figure 5C** since it simplifies the description.

Referring to the particular embodiment of **Figures 5A, 5B,** and **5C**, a first row of tiles covers from the horizon line to thirty degrees above the horizon. A second row of tiles covers from thirty degrees above the horizon to forty-two degrees above the horizon. A third, top, row of tiles covers the band from forty-two degrees above the horizon to fifty degrees above the horizon. The same angular divisions are used to divide the space below

the horizon. The row size divisions are nonlinear and widest at the horizon since users are usually most interested in views near the horizon. However, different angular divisions, such as linear angular divisions, may also be used.

After dividing each unwrapped panoramic image into tiles, a tile fetching program (**440** and **443**) fetches tiles for transmission to the client system. Ideally, the tile fetching program only selects the tiles needed to create a view on a client computer system. In a preferred embodiment, the client computer system determines which tiles are needed and sends a request that specifies which tiles should be selected. The fetched tiles are transmitted using a tile streaming program (**460** and **463**). By transmitting only the tiles needed to create a view on the client computer system, the system of the present invention limits the amount of information that must be transmitted from a panoramic image source server to a panoramic image client display.

Tile Tiering For Magnification

To accommodate several different magnification levels, several different sets of tile resolution may be created. For example, a low resolution "zoomed back" initial set of tiles may be used for panning around a panoramic image. The low resolution initial tiles would encompass a large angular view. When an interesting area of the panoramic image is selected, a higher resolution set of tiles could then be selected.

Figures 5D, **5E** and **5F** illustrate one possible embodiment where a panoramic image space has been divided into three tiers of magnification. An initial "zoomed back" tile magnification intermediate planar representation is presented in **Figure 5D**. The lower resolution intermediate planar representation of **Figure 5D** is used first. When a user wishes to see a portion of a view in greater detail, the client software "zooms in" by fetching tiles from the next higher resolution intermediate planar representation displayed in **Figure 5E**. If even greater resolution is needed, the client software "zooms in" further by fetching tiles from **Figure 5F**. In one embodiment, the pixel resolution of the individual tiles of **Figures 5D**, **5E** and **5F** is the same such that the individual tiles take up the same amount of screen space but provide successively greater resolution.

Tiling Without Transformation

As stated in the beginning of this section, the initial panoramic image frames need not be transformed into an intermediate planar representation before division into individual tiles. The intermediate planar representation transformation is usually performed since the transformation is used to put the image into a format that can be used to quickly generate an image for display with minimal processing. However, the raw panoramic image frames may immediately be divided into tiles and transmitted.

For example, **Figure 5G** illustrates a raw panoramic annular image frame from the panoramic camera system of **Figure 1**. Before transmitting, the raw panoramic annular image is divided into tiles. In the embodiment of **Figure 5G**, the raw panoramic annular image is divided into square tiles that are small near the center since a small tile covers a wide image area in the annular format. The middle part of the annular disk is divided into larger tiles. The outside of the annular disk is divided into smaller tiles since a narrow strip of tiles is needed when constructing a view that uses information from the edge of the annular disk. Thus, the tiles are spatially variant.

Tile Positional Selection

Figure 6A illustrates an example of a client system view into a panoramic image. Specifically, client view **630** represents a view into an unwrapped panoramic image **610** requested by a client computer system. The view is distorted since the view is illustrated within the spherical coordinate space. To construct the view **630** at a client system, a server (such as server **400**) transmits tiles **621**, **623**, **625**, and **627**. Each tile **621**, **623**, **625**, and **627** is compressed before transmission to further reduce the amount of information that needs to be transmitted. **Figure 6B** illustrates how the four tiles **621**, **623**, **625**, and **627** from the server are used to construct client view **630** on a client computer system. (The four tiles **621**, **623**, **625**, and **627** appear distorted since the tiles are displayed in the rectangular projection coordinate space of **Figure 6B**.)

Referring back to **Figure 6A**, if a user moves the view **630** further to the right, then the view will cease to need tiles **621** and **623** and will instead begin to need tiles **628** and **629**. To accommodate for such situations, the client system begins requesting tiles that are just slightly out of a current view when a view nears the edge of a tile in case the user moves further in that direction. Thus, in the example of **Figure 6A**, the client system would begin requesting tiles **628** and **629** when the view shifts a little further to the right. Thus, the tile fetching program in the server would fetch and transmit tiles **628** and **629** to the client system. Then, if the client view **630** progresses even further to the right, tiles **623**, **628**, **627**, and **629** would be used to construct the shifted client view in the client system.

In a preferred embodiment, the client computer system is responsible for determining when the out of view tiles are needed and when they should be transmitted. The client system makes this determination by examining factors such as how fast the user is moving the view, the latency of the connection with the server, and the parameters that define the views. The client computer system transmits a list of desired tiles to the server wherein the list of desired tiles define which tiles should be transmitted by the server to the client computer system.

The movement anticipation procedure described in the previous two paragraphs works well for small incremental client view shifts (which most view changes comprise). However, if a user makes a sudden quick view change, the needed tiles will not be available. For example, referring to **Figure 7**, a user may quickly shift a view from a first view position **730** to a second view position **740**. The first view position **730** was being rendered with tiles **721**, **723**, **725**, and **727** that were being sent a server. The new second view position **740** requires tiles **751**, **753**, **755**, and **757** which are not being transmitted.

To handle such sudden view changes, the present invention occasionally transmits a highly compressed version of the full panoramic image intermediate planar representation. The highly compressed panoramic image intermediate planar representation is only transmitted once every 30 or so normal frames. When a fast movement occurs, the client renders a view from the most recently received highly compressed panoramic image

intermediate planar representation. This newly rendered view will not be in the normal resolution since it is being rendered from the highly compressed panoramic image intermediate planar representation. Simultaneously, the server will begin transmitting the tiles needed at the new view location.

In the example of **Figure 7A**, the server will begin transmitting tiles **751**, **753**, **755**, and **757**. When tiles **751**, **753**, **755**, and **757** are received by the client computer system, the image rendered from the most recently received highly compressed panoramic image intermediate planar representation will be replaced with an image rendered from tiles **751**, **753**, **755**, and **757**. Thus, the new view image will become clearer once the server "catches up" to the users sudden view change.

A sudden movement may not move the view completely away from the currently available tiles. For example, a movement may place the view partially on tiles that are available and partially on tiles that are not available. In such a situation, the portion of the view that is located on available times can be rendered at the resolution of those tiles and the remainder of the view will be rendered using the highly compressed version. Similarly, if the user is "zoomed in" on high resolution tiles and the user moves quickly away from the currently available high resolution tiles, the view may be constructed using the tile from the next lower resolution tier if that tile is still available.

Figures 8 and **9** provide detailed flow diagrams that fully describe how the electronic image distribution system of **Figure 4** operates. **Figure 8** illustrates a flow chart describing one embodiment wherein a panoramic motion image server system and client system negotiate a connection. However, it should be noted that in other embodiments, a standard connection can be used such that there is no negotiation of connection parameters. **Figure 9** describes how a server system transmits image tiles to a client system.

<u>Client-Server Motion Panoramic Image Connection Negotiation</u>

Figure 4 illustrates one embodiment of a motion panoramic image client-server system wherein the bandwidth is conserved by dividing panoramic images into tiles.

It should be noted that there is often not a "standard" server and client environment. Specifically, the clients, the server, and the network in a client-server environment may all vary depending on the circumstances. The capabilities of each different panoramic server system and each different panoramic client system would vary depending upon the systems specifications including the computer make, the processor type, the processor generation, the amount of random access memory available, the bus speed, and the operating system.

To most efficiently distribute motion panoramic images from a motion panoramic image server to clients, the present invention has a client-server negotiation. The server system determines the characteristics of the client before determining how the client-server system will operate. **Figure 8** illustrates a flow diagram describing the method of negotiating the client-server motion panoramic image connection.

Referring to **Figure 8**, a client initiates a connection to a panoramic image server at step **810**. Next at step **820**, the panoramic image server requests information that describes the display characteristics the client. Specifically, the server may request the client's frame buffer size, the client's frame buffer color characteristics, the size of the panoramic image view window, and other information relevant to the display of images on the client system. The motion panoramic image server may also request information describing the processing abilities of the client. For example, the panoramic image server may request the processor type, the processor speed, and the amount of main memory available. The client responds to the server's by sending this information to the motion panoramic image server at step **830**.

At step **840**, the motion panoramic image server uses the collected information to determine how the server will serve the client. One specific parameter that the server must decide is how to divide the unwrapped panoramic intermediate planar representation into tiles. Specifically, the size of the individual tiles will be determined. The motion panoramic image server may also determine the video frame-rate, a type of compression to use, and a processing-task division based upon the network connection

speed and quality, the capabilities of the client system, and the current and anticipated processing load of the image server.

After determining the parameters of the motion panoramic image connection, the motion panoramic image server transmits the connection parameters to the client system at step **850**. The client system will use the parameters to determine how the client system will display motion panoramic images.

After the client and server have negotiated the motion panoramic image connection, the client begins requesting motion panoramic image information from the server system at step **860**. In response to the requests, the server begins transmitting motion panoramic image tiles to the client system at step **870**. Since the connection to each client is uniquely calibrated, the server will transmit panoramic image information to each different client in a manner that is specific to that particular client. The server will continue transmitting motion panoramic images until the client requests the server to stop sending images at step **880**.

Motion Panoramic Image Server Operation

Figure 9 describes how the motion panoramic image server transmits the information needed to construct a view within a motion panoramic image on a client system. Thus, **Figure 9** describes in detail what occurs during the steps **860** and **870** of **Figure 8**.

Referring to step **910** of **Figure 9**, the first step that the motion panoramic image server must perform is transforming a panoramic image frame into one or more intermediate planar representations. The exact method of transforming a panoramic image frame is dependent on the type of camera system used. For example, a system built using the panoramic camera system of **Figure 1** would perform a geometric transformation to transform the annular panoramic image frame into the selected intermediate planar representation. If a fisheye lens panoramic camera system were used, a different geometric transformation would transform the distorted fisheye image into the desired intermediate

planar representation. All subsequent actions are performed on the transformed intermediate planar representation.

In an embodiment with magnification, the source panoramic image data is transformed into more than one intermediate planar representations of different resolutions. For example, the source panoramic image data can be transformed into low, medium, and high resolution intermediate planar representations as illustrated in **Figures 5D, 5E** and **5F**.

After the panoramic image frame has been transformed into an intermediate planar representation, the method proceeds to step **920**. At step **920**, the method determines if a highly compressed version of the full panoramic image frame should be transmitted. As previously set forth, a highly compressed version of the full panoramic image frame is transmitted occasionally to handle sudden movements of the clients view. In one embodiment, the motion panoramic image server transmits a highly compressed version of the full panoramic image frame during first and every Nth subsequent frame. Thus, during the first and every Nth subsequent frame, the method proceeds to step **970** where the full panoramic image frame is compressed. Then, at step **980**, the motion panoramic image server begins transmitting the highly compressed version of the full panoramic image frame. The transmission of the highly compressed version of the full panoramic image frame may occur all at once. Alternatively, the highly compressed version of the full panoramic image frame may be transmitted concurrently along with individual image tiles such that individual image tiles are not delayed.

Next, at step **930**, the one or more intermediate planar representation frames are divided into individual tiles as illustrated in **Figures 5D, 5E** and **5F**. The size of the individual tiles is the size that was negotiated during the connection process described in the flow diagram of **Figure 8**.

After the frame has been divided into individual tiles, the server then fetches and transmits the tiles needed to create the client's view at step **940**. Each tile is compressed

before transmission to conserve bandwidth and decrease latency. The client will use the transmitted tiles to construct a image.

At step **950**, the server method determines if the client system is done viewing the motion panoramic image. If the client is not done, the method proceeds back to step **960**.

Motion Panoramic Image Server Operation

Figure 10 illustrates a flow diagram describing a method that a client system may follow to receive information from render an image. It should be noted that **Figure 10** only illustrates one possible embodiment of a client system and that significant variations may be created. For example, several of the steps described in **Figure 10** such as receiving tiles and rendering an image may be performed concurrently. Alternatively, less processing could be performed in the client system and more processing could be performed in the server.

Referring to step **1010** of **Figure 10**, the client receives any and all request panoramic image tiles and highly compressed full panoramic images transmitted by the server. At step **1020**, the client attempts to render an image for the current view position. Ideally, the view will be rendered with the tiles needed for the view. However, if the client does not have the desired tiles, then the client renders an image of the current view using the available tiles for the view, tiles from lower resolution tiers, and the most recently received version of the highly compressed full panoramic image.

After rendering an image frame, the client system accepts input from a user at step **1030**. The client system may accept input such as directional commands from a computer mouse that pan the view within the panoramic image. The client may also accept commands that zoom-in and change the vertical viewing angle.

The client system then processes the user input to the server system at step **1030** to determine a next view position. At step **1040**, the client system determines if the

input specifies that the user is done viewing the panoramic image information. The client panoramic image rendering program will terminate when the user no longer wishes to view the panoramic image.

At step **1050** the client system determines the frame tiles that are needed to create the new view position. The client system also determines if it should request tiles that are just out of the current view but are likely to be needed in the future. Specifically, the client determines if the current view is near the edge of a tile. If the client's view is near the edge of a tile, then the client will request tiles that are just outside of the client's current view. The tiles just out of view are requested such that if the client moves the view beyond the edge of the tile, then the client will be able to create a view without having to request and wait for the server to then send the needed tile. Thus, the client anticipates small view movements and is prepared to generate a view. However, if the user makes a sudden large view change, then the client rendering engine can always fall back to the highly compressed version of the full panoramic image.

Furthermore, at step **1050**, the client system determines if any currently requested tiles are no longer needed. Tiles that are no longer needed consume valuable bandwidth such that the client system should unsubscribe from tiles that are no longer needed.

After determining the tiles needed for the current view, the client system determines at step **1060** if the needed tiles have already been requested and if there are no unnecessary tiles on request. If the needed tiles have already been requested and there are no unnecessary tiles on request, then the client system does not need to change the tile subscriptions. However, if new tiles are needed or currently subscribed tiles are no longer needed, then the client system sends a request to the server at step **1070** that changes the tile subscription.

At step **1080** the client system determines if any new frame tiles or compressed panoramic image frames have been received. If new frames have been

received, then the method proceeds back to step **1010** to accept the new frames. Otherwise, the method proceeds back to step **1020** to render a new view image using the currently available tiles and the highly compressed full panorama image information. A different image may be generated from the same frame information if the user has shifted the view.

Overlapping Tile embodiment

In one proposed embodiment, the panoramic image intermediate planar representation is divided into overlapping tiles. An example of this is provided in **Figure 11**. By dividing the intermediate planar representation into overlapping tiles, a degree of Hysteresis is provided such that small back and forth view changes will not cause the client system to oscillate requests for new tiles.

A Second Motion Panoramic Image Distribution System Embodiment

The selective tile transmission system described in the previous section provides a useful method of delivering motion panoramic image information in a unicast environment where each client receives a unique individual data stream. However, since the motion panoramic server must send out a unique data stream to each client, there will be a significant amount of redundant information being transmitted. To reduce the amount of redundant information being transmitted, the present invention also introduces a second multicast motion panoramic image serving system.

Figure 12 illustrates a multicast motion panoramic image serving system constructed according to the teachings of the present invention. In the system of **Figure 12**, a motion panoramic camera system **1205** delivers a series of high resolution panoramic images across a high bandwidth link **1202** to a motion panoramic server **1200**. A Panoramic Camera Interface **1210** handles the communication with the motion panoramic camera system **1205**. A transformation unit **1217** transforms the raw panoramic image frames into an intermediate planar representation. As previously set forth, two possible intermediate planar representations are cylindrically encoded intermediate planar representation and spherically encoded intermediate planar representation.

After a panoramic image frame has been transformed into an intermediate planar representation, the intermediate planar representation is divided into individual tiles by unit **1241**. After dividing the intermediate planar representation into individual tiles, a set of tile streaming units **1261**, **1262**, **1263**, . . . **126n** transmit the tiles on multicast channels **1293** on a high bandwidth network **1290**. Specifically, each tile position is assigned its own multicast channel.

To display a view within a motion panoramic image, each client system subscribes to the multicast channels that carry the tiles needed to construct the desired view. For example, client system **1295** needs the two tiles delivered by tile streaming units **1261** and **1262** such that client system **1295** subscribes to the multicast channels transmitted by those tile streaming units.

Figure 13 provides a flow diagram that describes one possible method that a client system may follow to render a view from a motion panoramic server constructed according to the teachings of **Figure 12**. Initially, at step **1310**, the client system subscribes to the multicast panoramic tile channels necessary to render a view from an initial view location. Routers and switches that couple the client system to a main multicast backbone will perform the necessary operations in order to begin delivering the subscribed multicast panoramic tile channels.

Next, at step **1320**, the client system will render an image of the current view using the information from the subscribed multicast panoramic tile channels. It should be

noted that other client systems will share the same multicast channels such that bandwidth is conserved.

At step **1330**, the client system accepts input from the user. The client system may accept input such as directional commands from a computer mouse that pan and tilt the user's view within the motion panoramic image.

After accepting the user's input, the client system analyzes the user's input. If the user has indicated that he is done viewing the motion panoramic image at step **1340**, then the client system unsubscribe to all the multicast tile channels will stop displaying images as set forth in step **1370**.

If the user's input changes the position of the view within the motion panoramic image, then the client system determines the tiles that will be necessary to render the new view position at step **1350**. Specifically, referring back to **Figure 5**, the client system determines which files comprise the current view location. At step **1360**, the client determines if only the same tiles that are already subscribed to are needed. If so, then the method proceeds back to step **1320** to render a subsequent image view frame.

If different tiles are needed, then the client system proceeds to step **1310**. At step **1310**, the client system subscribes to the multicast tile channels needed to render the current view.

To limit the number of multicast channels used, the number of tiles that the panoramic image is divided into should be kept small. **Figure 14** illustrates one possible way of dividing the original source panorama. In the embodiment of **Figure 14**, the source panorama is divided into four quadrants: an upper quadrant, a left quadrant, a right quadrant, and a lower quadrant. (The quadrant are illustrated using dotted lines.) Each quadrant becomes the source of a multicast channel. Thus, only four multicast channels are required.

To handle pans of the user's view, the information supplied for each quadrant should overlap the other quadrants such that only one multicast channels needs to be subscribed to. Ideally, the overlap area will be at least as large as a client view. Referring to **Figure 14**, a set of overlapping quadrants are displayed: overlapping upper quadrant **1410**, overlapping left quadrant **1420**, overlapping lower quadrant **1430**, overlapping right quadrant **1440**.

If very fast pans occur, the multicasting embodiment may also include a highly compressed full panoramic image channel. The highly compressed full panoramic image channel would occasionally transmit a highly compressed version of the full panoramic image such that a view in any direction could be created.

To divide the processing that must be performed, multiple servers may be used. For example, a first server could generate and serve the multicast channel carrying the overlapping upper quadrant **1410**, a second server could generate and serve the multicast channel carrying the overlapping left quadrant **1420**, and so on.

Figure 15 graphically illustrates how network bandwidth is conserved using a multicast type of system. Specifically, a panoramic image server transmits all the tile channels on a multicast backbone. Various routers coupled to the multicast backbone only route multicast channels subscribed to by clients connected to their subnetworks. By routing only the multicast channels needed by clients connected to their subnetworks, the routers limit the tile information carried by the subnetworks.

The foregoing has described methods and apparatuses for electronically distributing motion panoramic images. It is contemplated that changes and modifications may be made by one of ordinary skill in the art, to the materials and arrangements of elements of the present invention without departing from the scope of the invention.

CLAIMS

We claim:

1. An electronic image distribution apparatus, said apparatus comprising:

a motion panoramic image source, said motion panoramic image source providing successive frames of panoramic images;

a division unit, said division unit dividing said successive frames of panoramic images into tiles, said tiles being spatially variant; and

a transmitter, said transmitter transmitting a first set selected tiles to a first client system to construct a view in said client system.

2. The electronic image distribution apparatus as claimed in claim 1 wherein said transmitter divides said tiles into a size also dependent upon said first client system.

3. The electronic image distribution apparatus as claimed in claim 1 further comprising:

a transformation unit, said transformation unit transforming said successive frames of panoramic images into an intermediate planar representation before passing said frames to said division unit.

4. The electronic image distribution apparatus as claimed in claim 3 wherein said intermediate planar representation is a spherical projection representation.

5. The electronic image distribution apparatus as claimed in claim 3 wherein said intermediate planar representation is a cylindrical projection representation.

6. The electronic image distribution apparatus as claimed in claim 3 wherein said transformation unit creates more than one intermediate planar representation wherein each intermediate planar representation has different resolution levels.

7. The electronic image distribution apparatus as claimed in claim 1 wherein said panoramic image frames comprise an annular panoramic image format.

8. The electronic image distribution apparatus as claimed in claim 1 wherein said transmitter compresses said tiles.

9. The electronic image distribution apparatus as claimed in claim 1 further comprising:

a compression unit, said compression unit occasionally compressing one of said successive frames of panoramic images into a highly compressed format and transmitting said highly compressed format to said first client system.

10. The electronic image distribution apparatus as claimed in claim 9 wherein said compression unit compresses every Nth of said successive frames of panoramic images into said highly compressed format.

11. The electronic image distribution apparatus as claimed in claim 1 wherein said client system requests said first set of selected tiles.

12. The electronic image distribution apparatus as claimed in claim 1 wherein said transmitter further transmits a second set of selected tiles to a second client system.

13. The electronic image distribution apparatus as claimed in claim 12 wherein said second client system requests said second set of selected tiles.

14. The electronic image distribution apparatus as claimed in claim 1 wherein said tiles overlap each other.

15. The elcctronic image distribution apparatus as claimed in claim 1 wherein transmitter transmits more than just the tiles needed to render said view in said client system.

16. A method of distributing electronic images, said method comprising the steps of:

capturing a panoramic image frame;

dividing said panoramic image into a plurality of tiles, said tiles being spatially variant; and

selectively transmitting a subset of said plurality of tiles to a first client system.

17. The method of distributing electronic images as claimed in claim 16 further comprising:

transforming said panoramic image frame into an intermediate planar format.

18. The method of distributing electronic images as claimed in claim 17 wherein said intermediate planar representation comprises a spherical projection representation.

19. The method of distributing electronic images as claimed in claim 17 wherein said intermediate planar representation comprises a cylindrical projection representation.

20. The method of distributing electronic images as claimed in claim 17 wherein transforming said raw panoramic image frame comprises transforming said raw panoramic image frame into more than one intermediate planar format wherein each intermediate planar format has a different resolution level.

21. The method of distributing electronic images as claimed in claim 17 wherein said tiles are divided into a size further dependent upon said first client system.

22. The method of distributing electronic images as claimed in claim 16 wherein said first client system specifies which tiles must be transmitted to render a view on said client system.

23. The method of distributing electronic images as claimed in claim 16 wherein said client requests outside tiles just outside of said view in case said client system needs said outside tiles for a future view.

24. The method of distributing electronic images as claimed in claim 16 further comprising

transforming said raw panoramic image frame into a highly compressed intermediate planar format frame; and

transmitting said highly compressed intermediate format frame to said first client system.

25. The method of distributing electronic images as claimed in claim 16 wherein said subset of said plurality of tiles are compressed before being transmitted.

26. The method of distributing electronic images as claimed in claim 16 wherein said plurality of tiles overlap each other.

27. The method of distributing electronic images as claimed in claim 16 further comprising:

selectively transmitting a second subset of said plurality of tiles to a second client system.

28. An electronic image distribution apparatus, said apparatus comprising:

a motion panoramic image source, said motion panoramic image source providing successive frames of panoramic images;

a divider, said divider dividing said successive frames of panoramic images into a set of individual tiles; and

a transmitter, said transmitter transmitting tiles on multicast channels.

29. The electronic image distribution apparatus as claimed in claim 28 further comprising.

a transformation unit, said transformation unit transforming said successive frames of panoramic images into intermediate planar format;

30. The electronic image distribution apparatus as claimed in claim 29 wherein said intermediate planar format comprises a spherical projection representation.

31. The electronic image distribution apparatus as claimed in claim 29 wherein said intermediate planar representation comprises a cylindrical projection representation.

32. The electronic image distribution apparatus as claimed in claim 28 wherein said successive frames of panoramic images comprise annular panoramic image frames.

33. The electronic image distribution apparatus as claimed in claim 28 further comprising:

a first client system, said first client system subscribing to a first set of multicast channels needed to render an image.

34. The electronic image distribution apparatus as claimed in claim 33 further comprising:

a second client system, said second client system subscribing to a second set of multicast channels needed to render an image.

35. The electronic image distribution apparatus as claimed in claim 28 wherein said transmitter compresses said individual tiles.

36. The electronic image distribution apparatus as claimed in claim 28 wherein said multicast channels comprise multicast streams on the Internet.

37. An electronic image distribution method, said method comprising:

capturing successive frames of panoramic images;

dividing said intermediate format frames into a set of individual tiles, said tiles being spatially variant; and

transmitting said individual tiles on individual multicast channels.

38. The method as claimed in claim 37 further comprising:

transforming said successive frames of panoramic images into an intermediate planar representation.

39. The method as claimed in claim 37 further comprising:

subscribing a first client system to multicast channels needed to render a first view into said panoramic image on said first client system.

40. The method as claimed in claim 39 further comprising:

subscribing a second client system to multicast channels needed to render a second view into said panoramic image on said second client system.

41. The method as claimed in claim 37 wherein said individual tiles are compressed before transmitting.

42. The method as claimed in claim 37 wherein said multicast channels comprise multicast streams on the Internet.

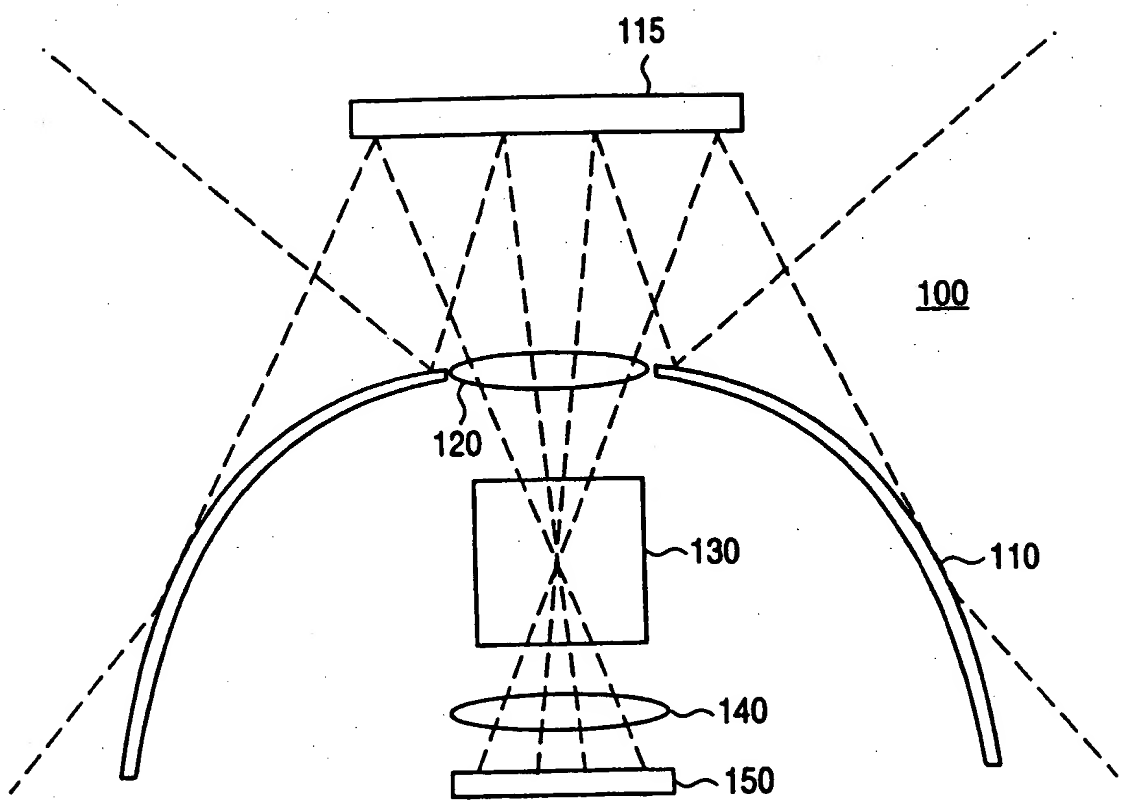


FIG. 1

FIG. 2a

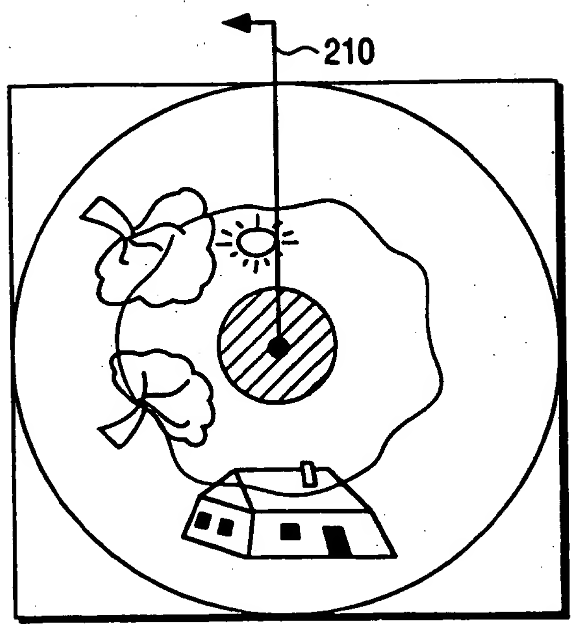
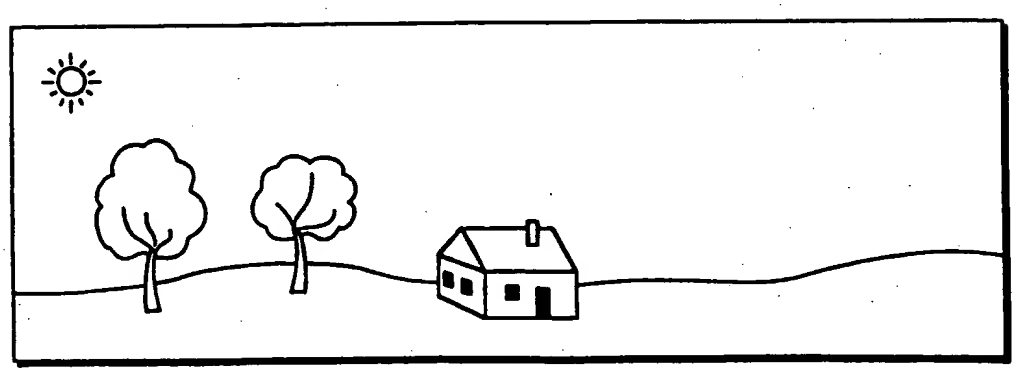


FIG. 2b



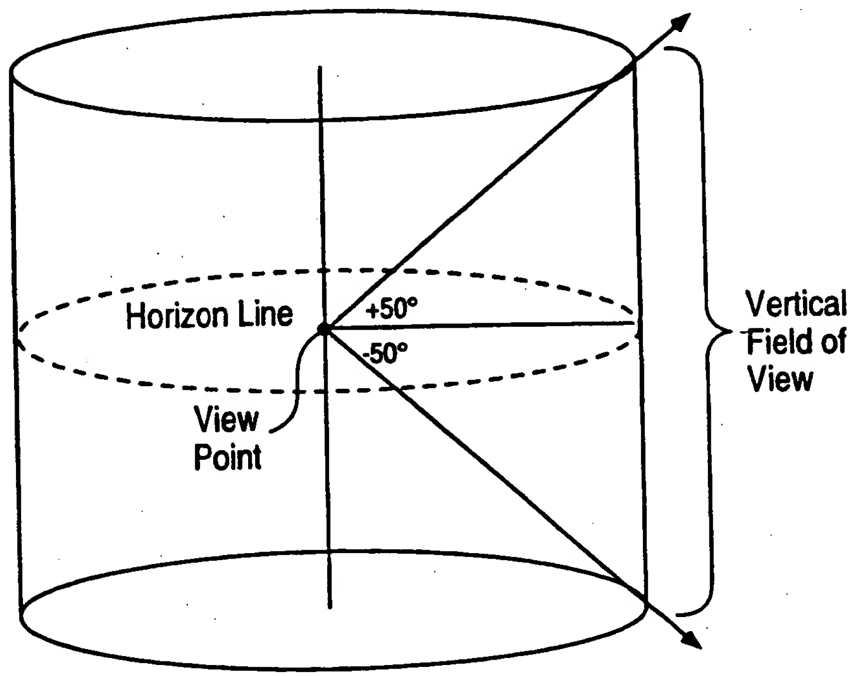


FIG. 3

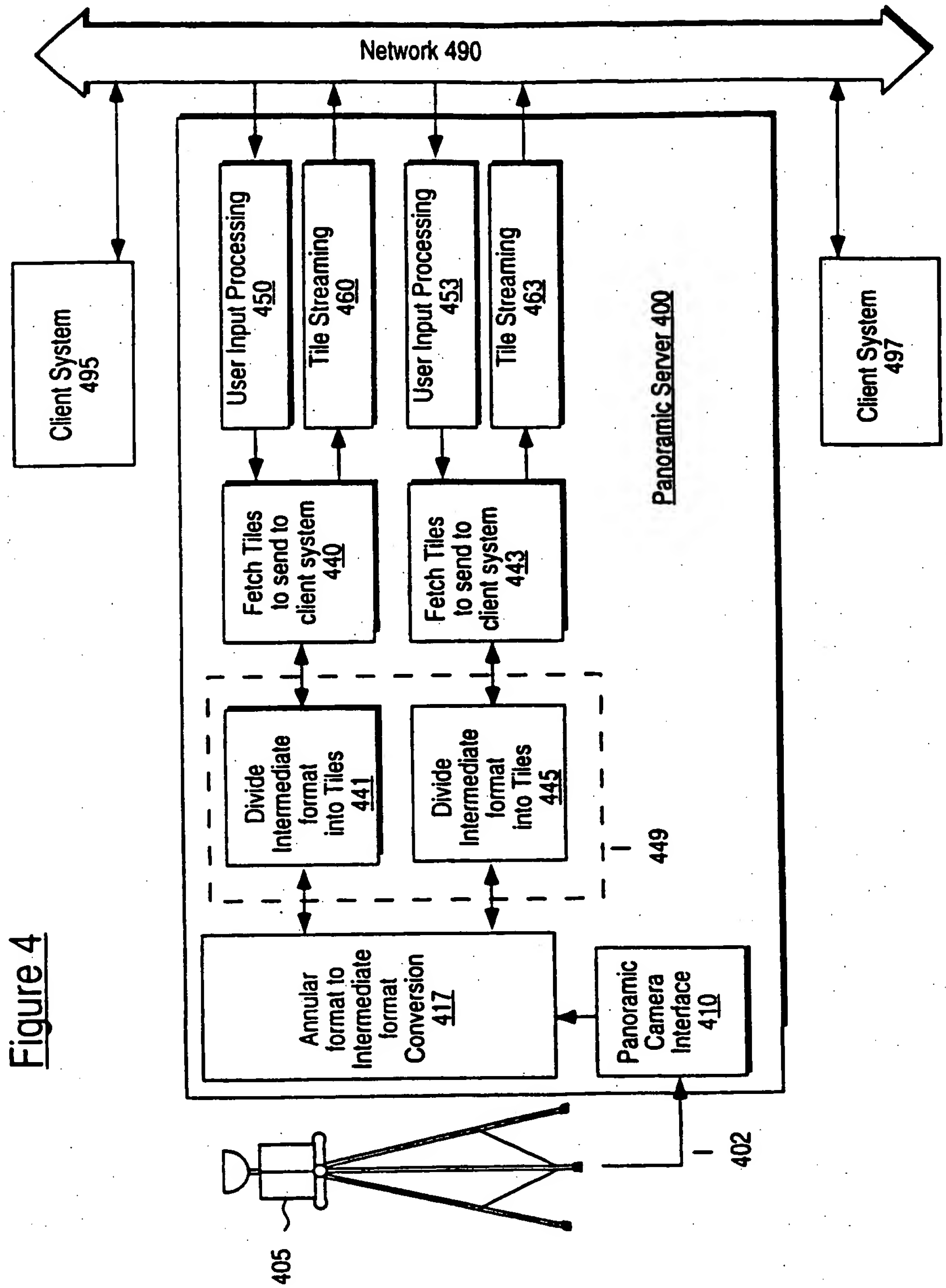

Network 490
Client System 495
Client System 497
User Input Processing 450
Tile Streaming 460
User Input Processing 453
Tile Streaming 463
Panoramic Server 400
Fetch Tiles to send to client system 440
Fetch Tiles to send to client system 443
Divide Intermediate format into Tiles 441
Divide Intermediate format into Tiles 445
449
Annular format to Intermediate format Conversion 417
Panoramic Camera Interface 410
402
405

Figure 4

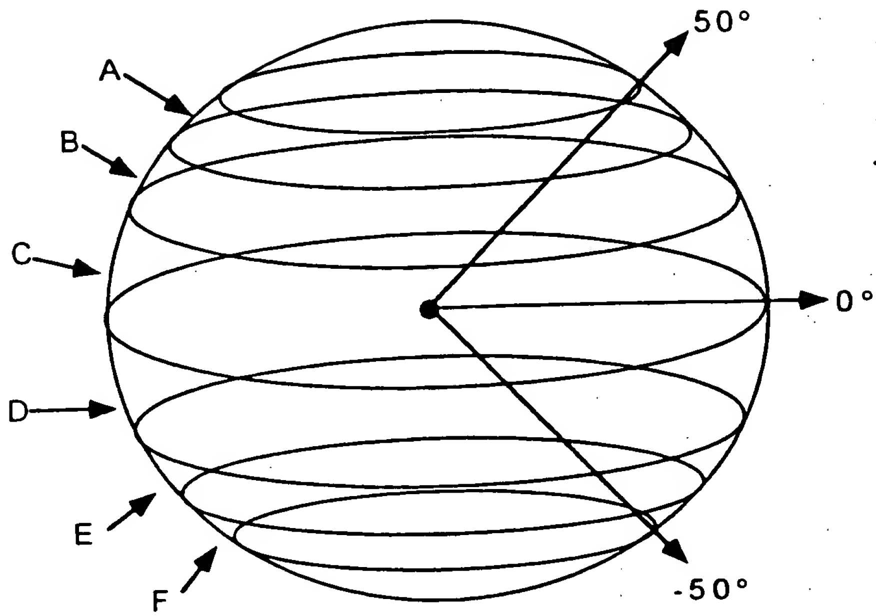


Figure 5A

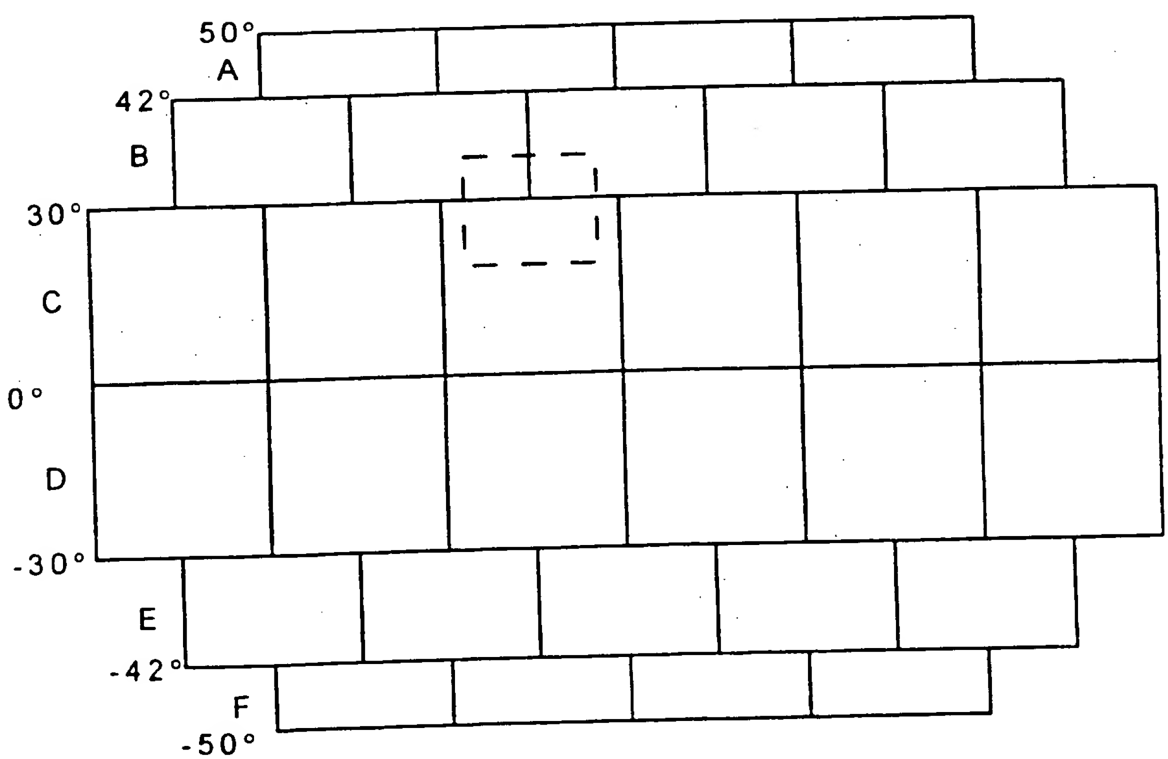


Figure 5B

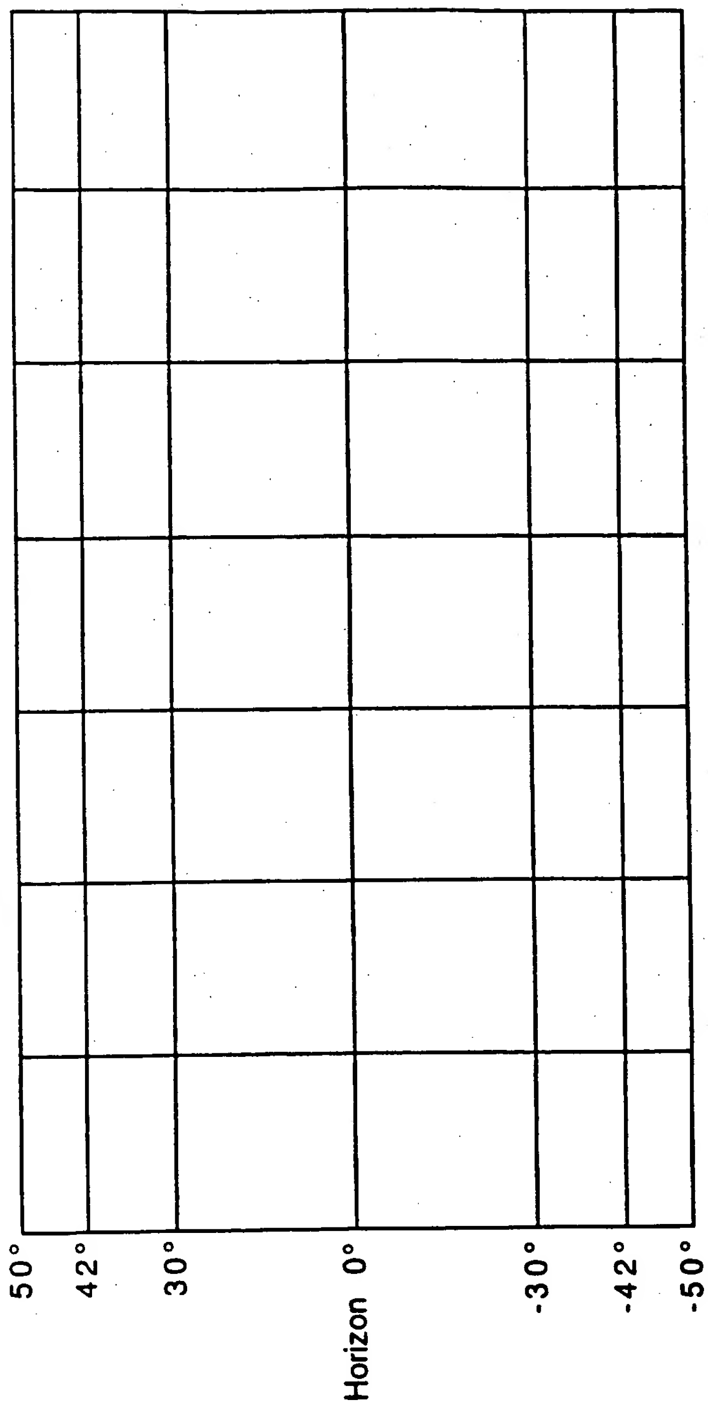


Figure 5C

Figure 5D

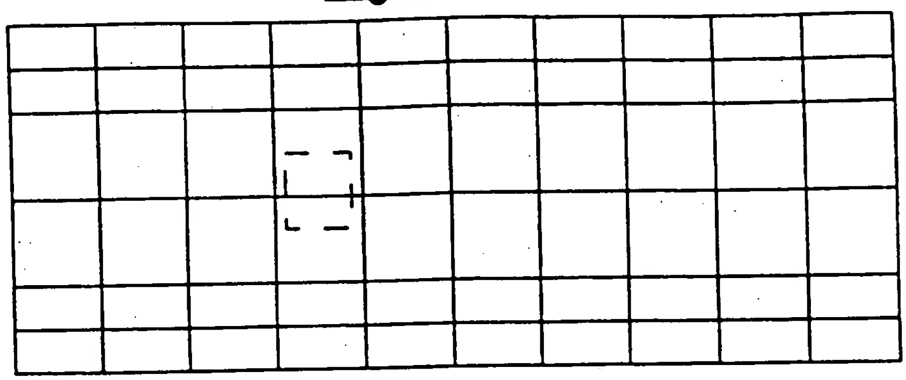


Figure 5E

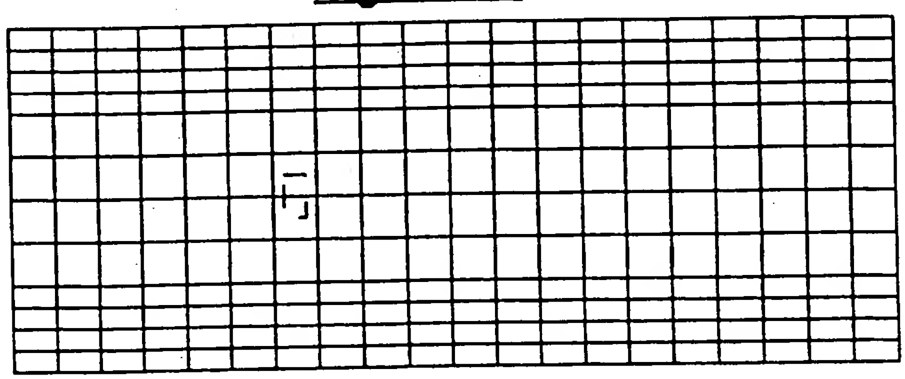


Figure 5F

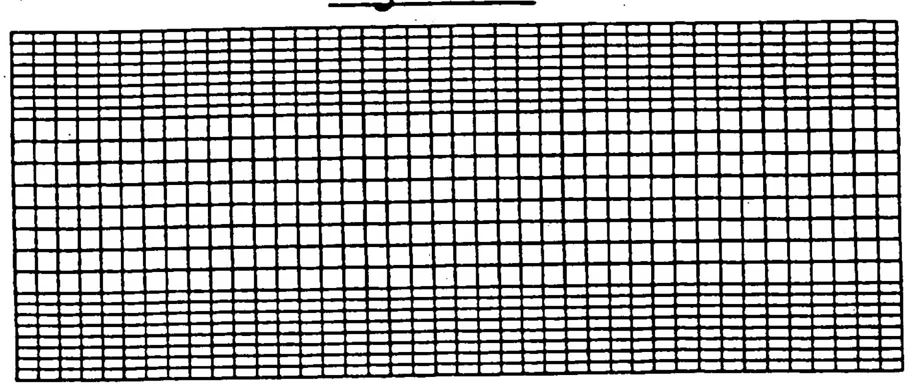
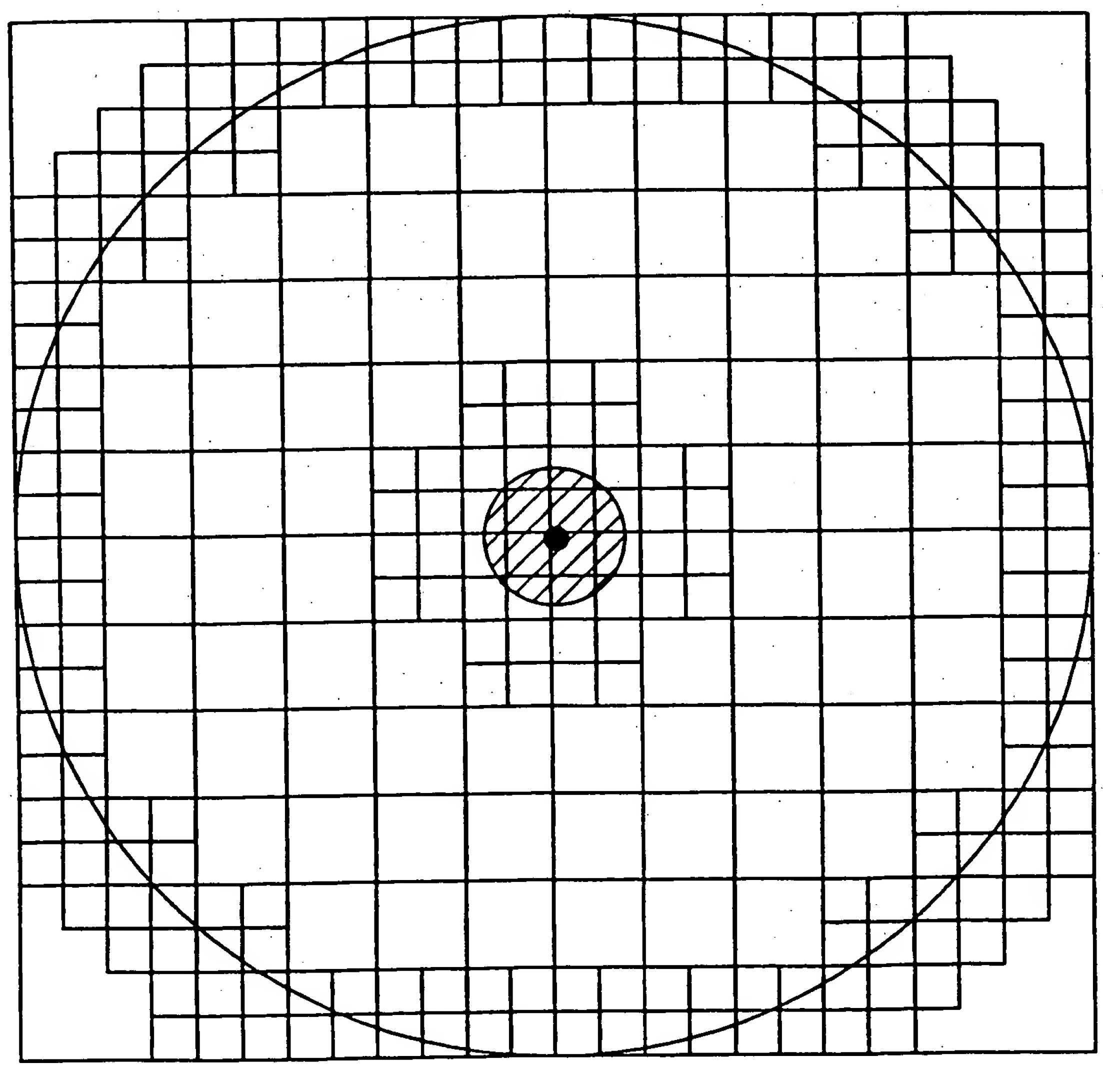


Figure 5G



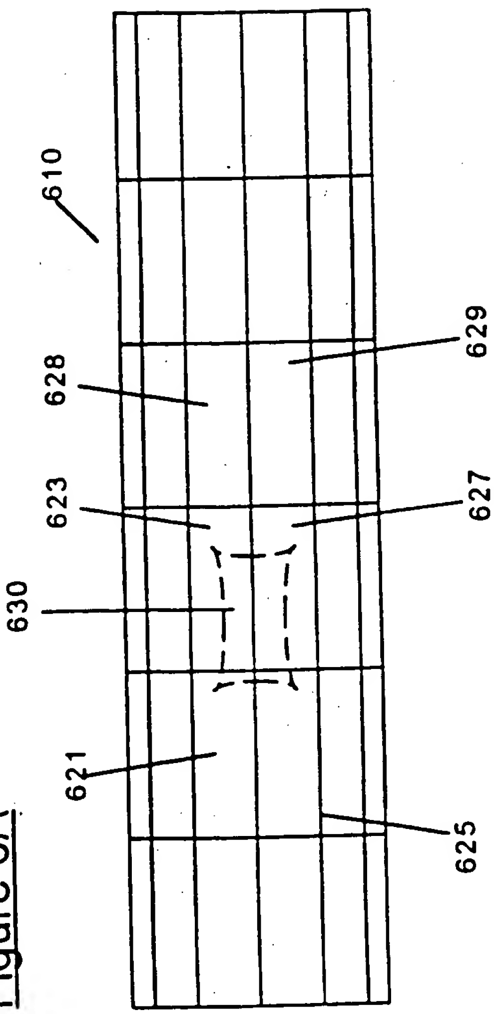


Figure 6A

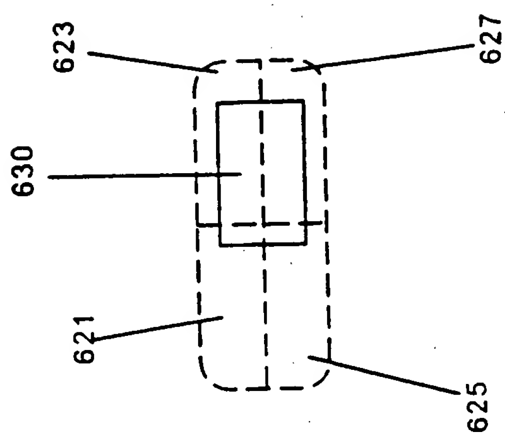


Figure 6B

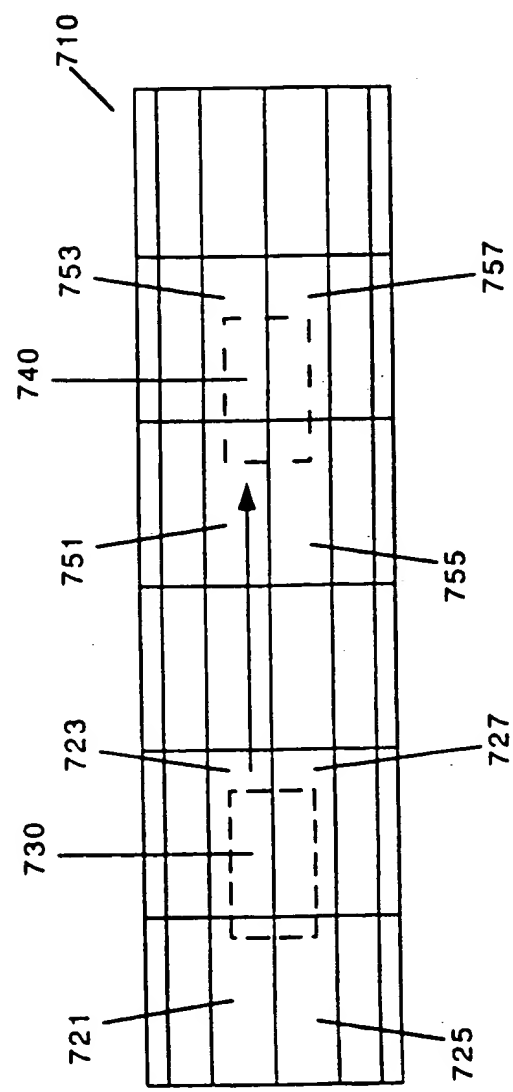


Figure 7A

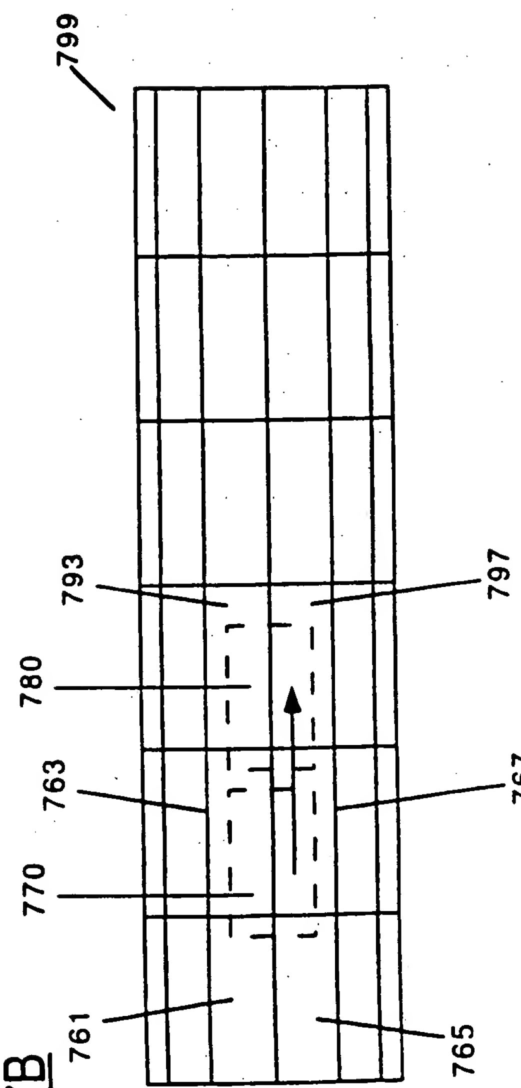


Figure 7B

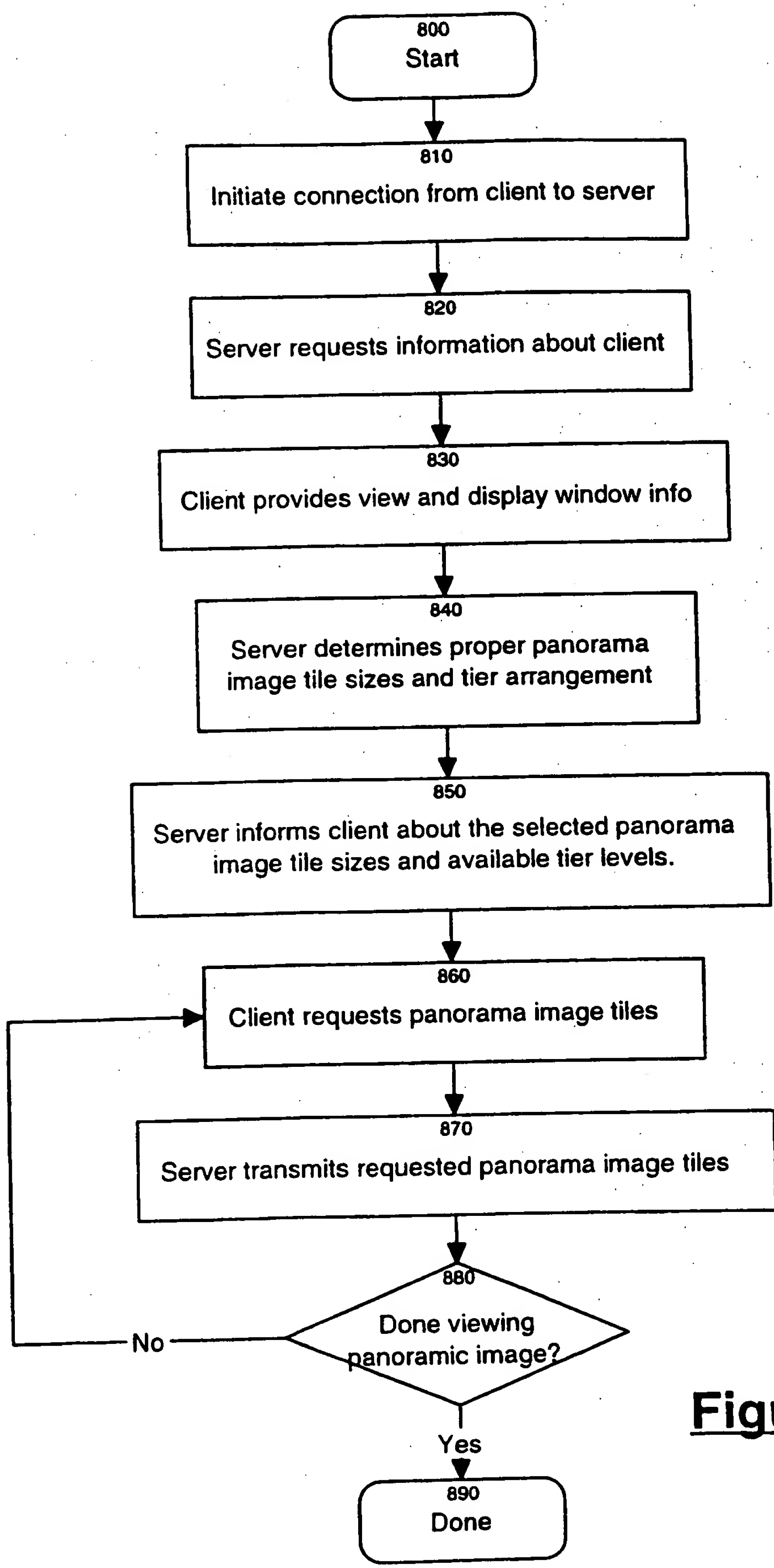

800
Start
810
Initiate connection from client to server
820
Server requests information about client
830
Client provides view and display window info
840
Server determines proper panorama image tile sizes and tier arrangement
850
Server informs client about the selected panorama image tile sizes and available tier levels.
860
Client requests panorama image tiles
870
Server transmits requested panorama image tiles
880
Done viewing panoramic image?
No
Yes
890
Done

Figure 8

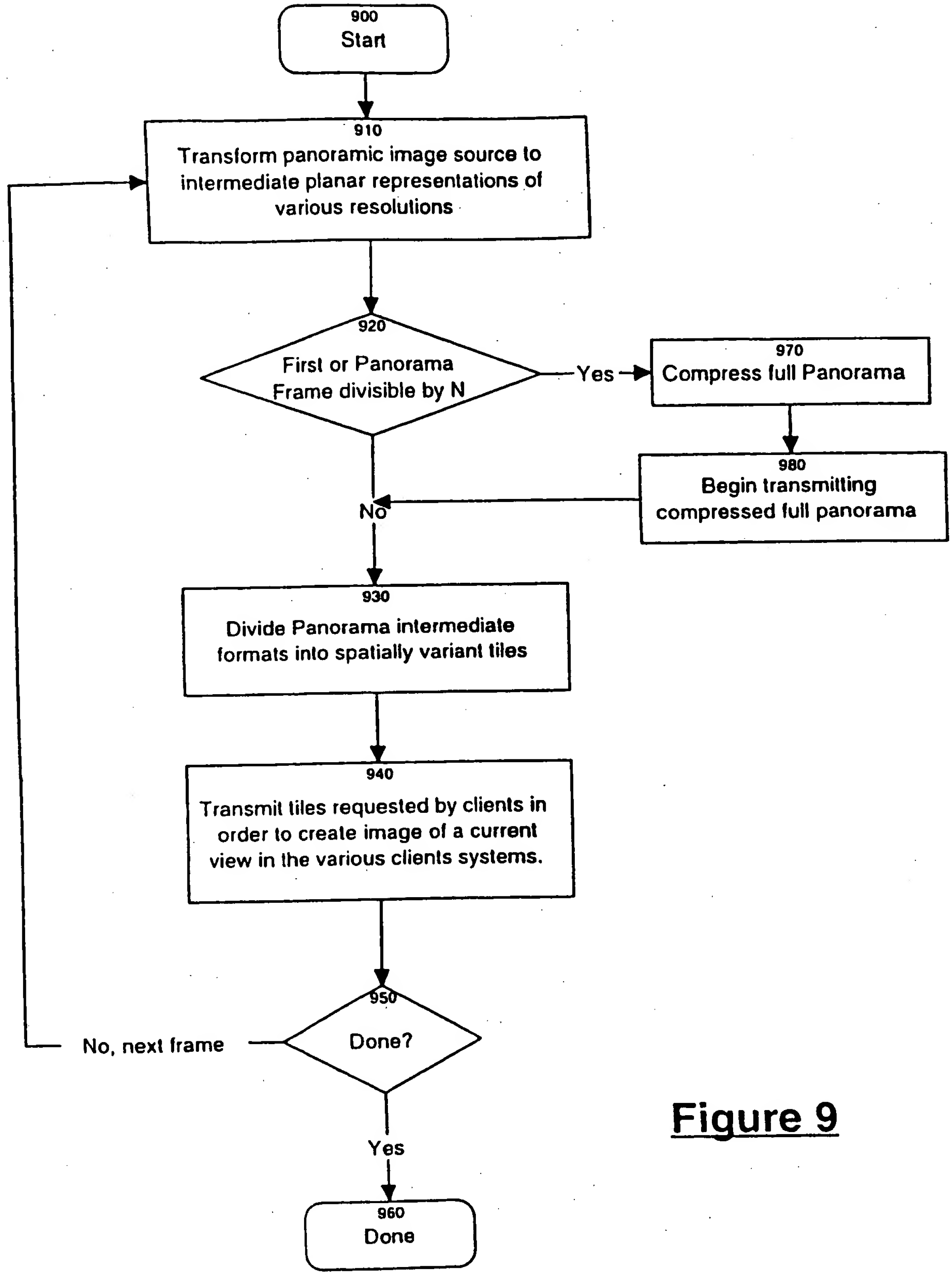
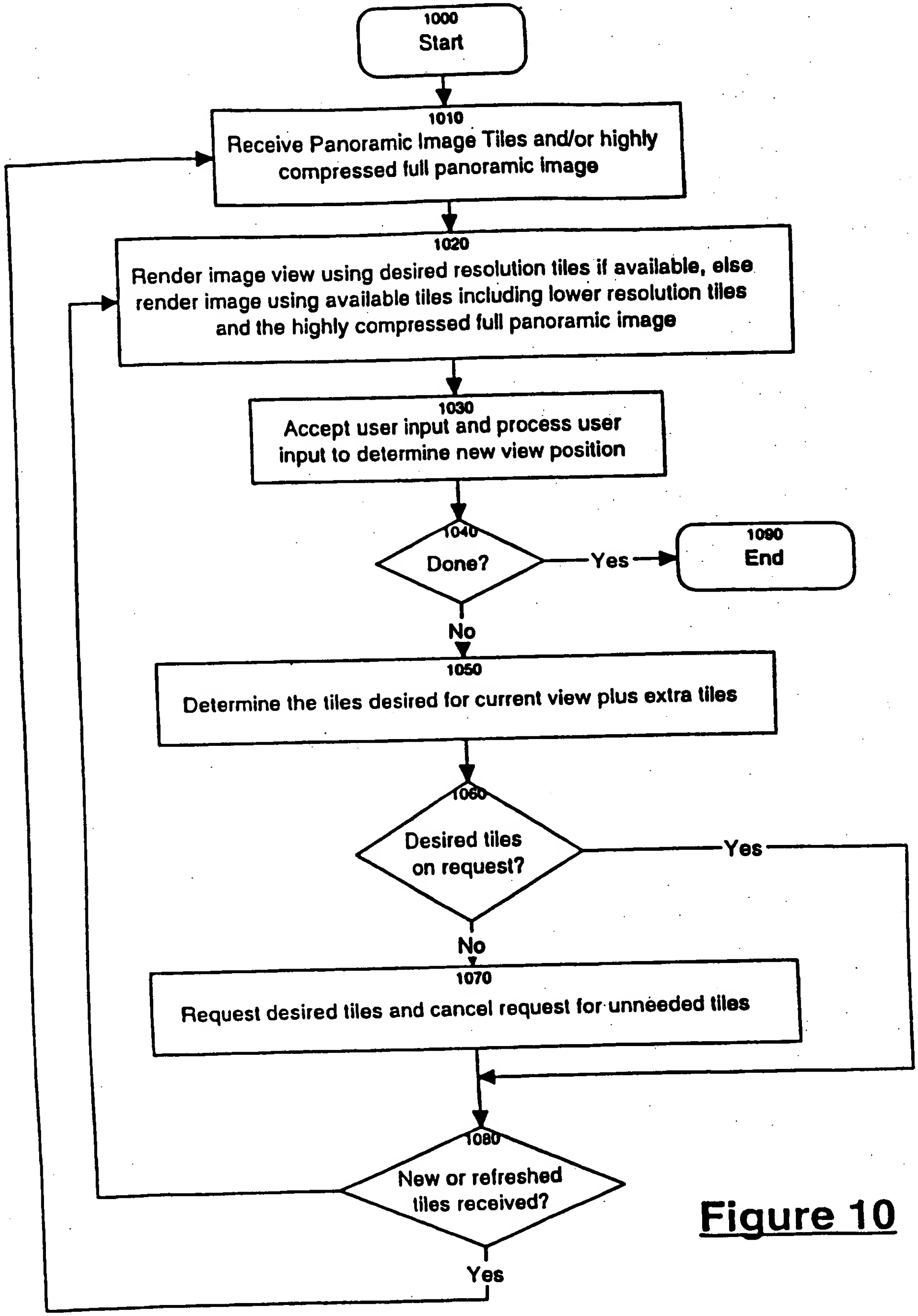

900
Start
910
Transform panoramic image source to intermediate planar representations of various resolutions
920
First or Panorama Frame divisible by N
Yes
970
Compress full Panorama
980
Begin transmitting compressed full panorama
No
930
Divide Panorama intermediate formats into spatially variant tiles
940
Transmit tiles requested by clients in order to create image of a current view in the various clients systems.
950
Done?
No, next frame
Yes
960
Done

Figure 9



1000
Start
1010
Receive Panoramic Image Tiles and/or highly compressed full panoramic image
1020
Render image view using desired resolution tiles if available, else render image using available tiles including lower resolution tiles and the highly compressed full panoramic image
1030
Accept user input and process user input to determine new view position
1040
Done?
Yes
1090
End
No
1050
Determine the tiles desired for current view plus extra tiles
1060
Desired tiles on request?
Yes
No
1070
Request desired tiles and cancel request for unneeded tiles
1080
New or refreshed tiles received?
Yes

Figure 10

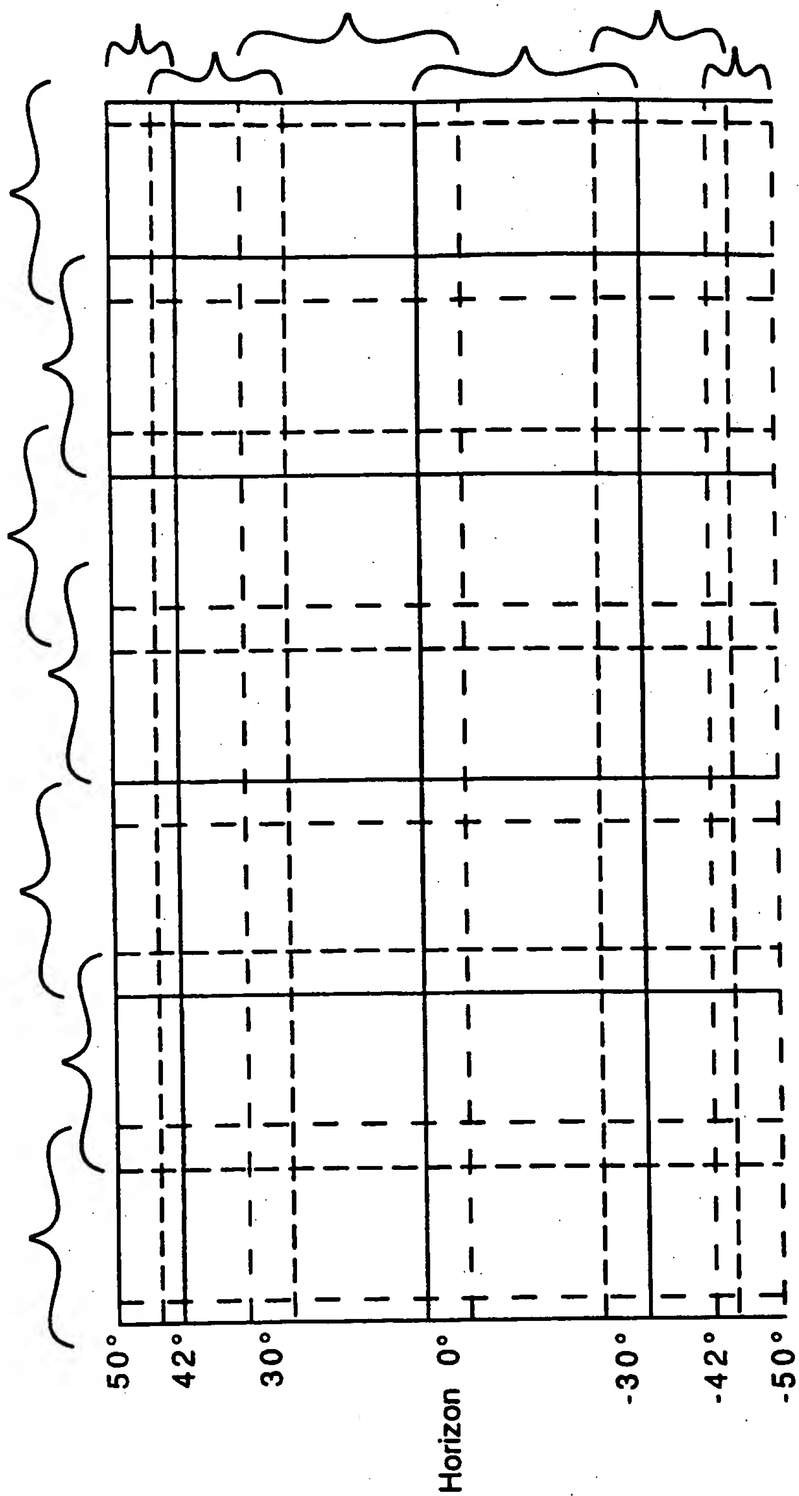


Figure 11

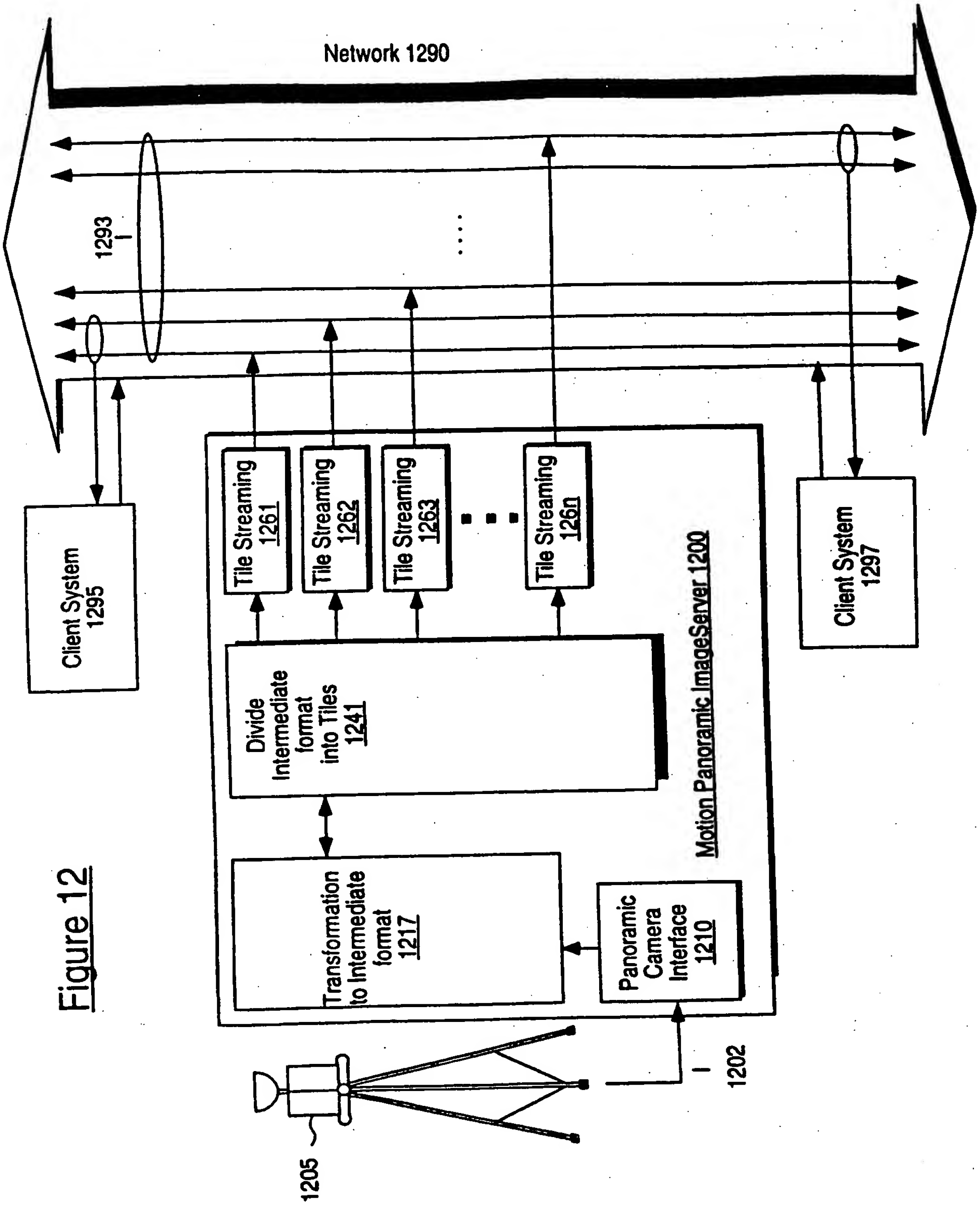

Network 1290
1293
Client System 1295
Tile Streaming 1261
Tile Streaming 1262
Tile Streaming 1263
Tile Streaming 126n
Client System 1297
Divide Intermediate format into Tiles 1241
Motion Panoramic ImageServer 1200
Transformation to Intermediate format 1217
Panoramic Camera Interface 1210
1202
1205

Figure 12

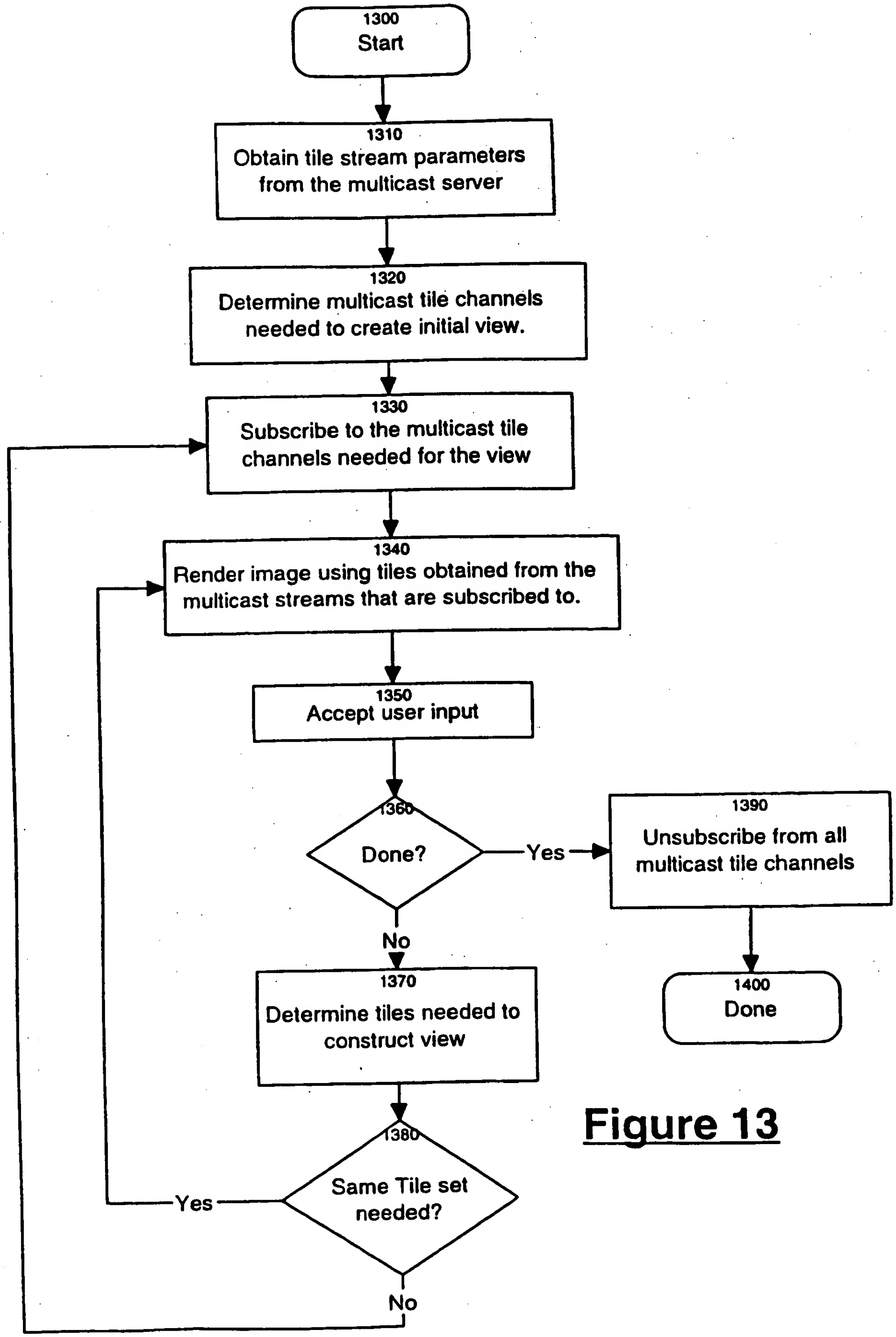
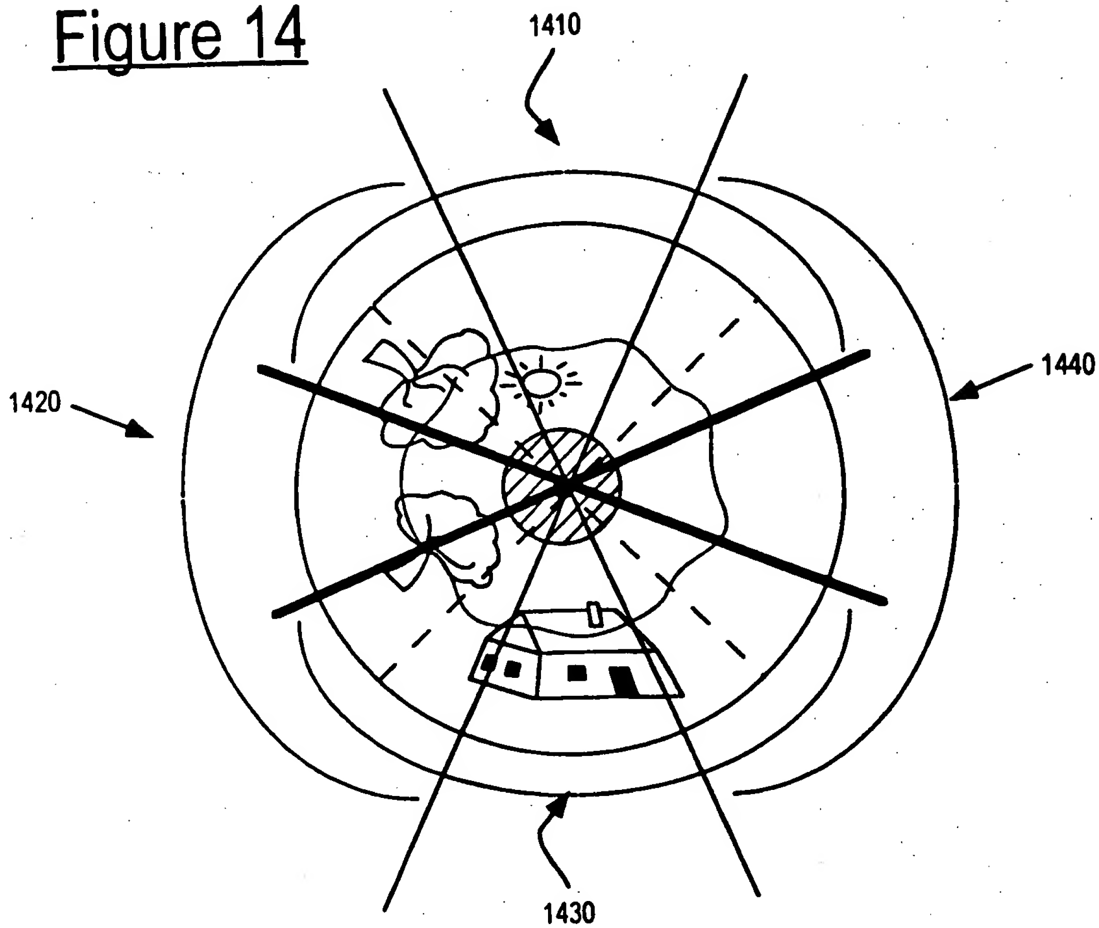

1300
Start
1310
Obtain tile stream parameters from the multicast server
1320
Determine multicast tile channels needed to create initial view.
1330
Subscribe to the multicast tile channels needed for the view
1340
Render image using tiles obtained from the multicast streams that are subscribed to.
1350
Accept user input
1360
Done?
Yes
1390
Unsubscribe from all multicast tile channels
1400
Done
No
1370
Determine tiles needed to construct view
1380
Same Tile set needed?
Yes
No

Figure 13

Figure 14



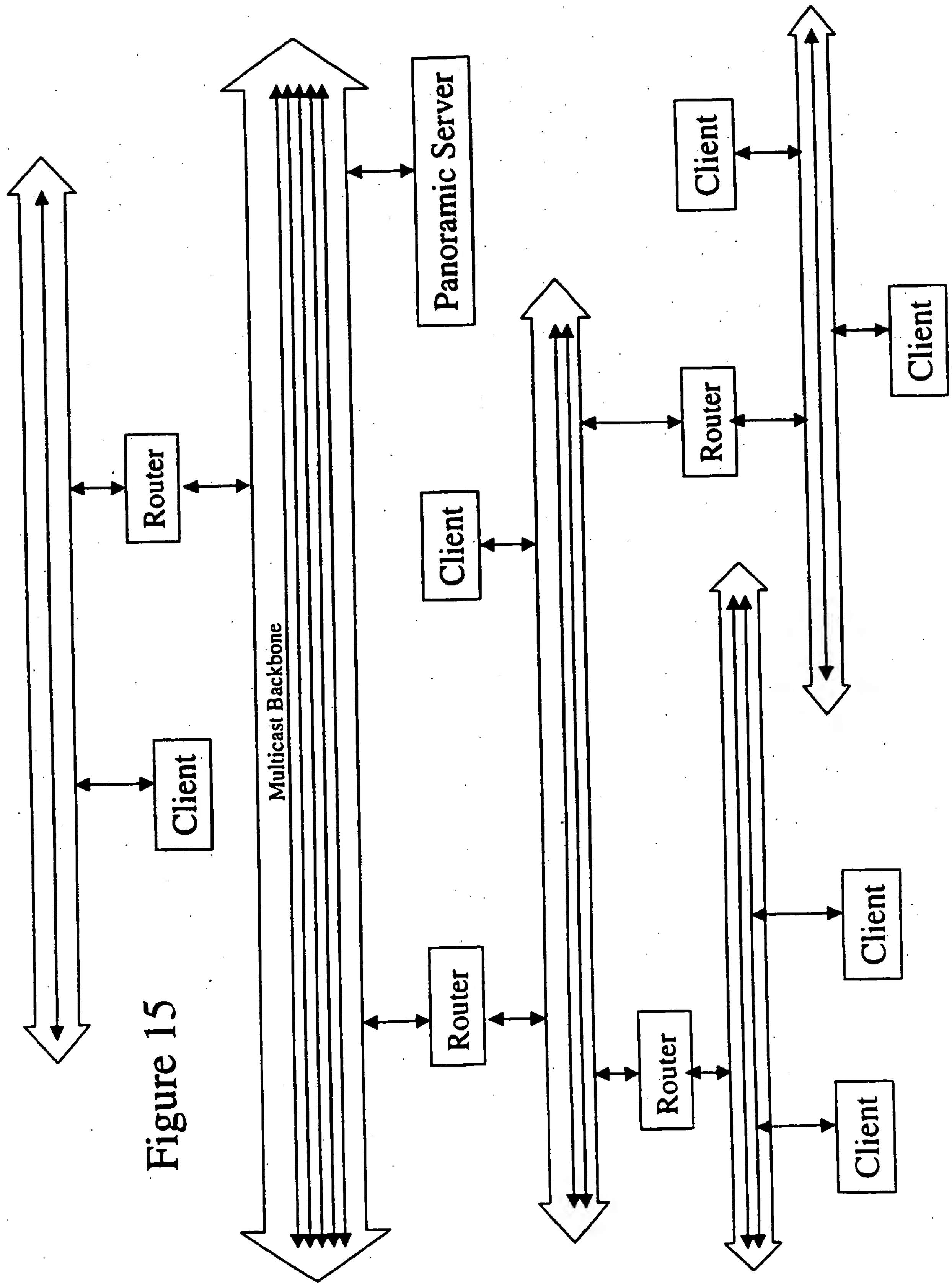

Panoramic Server
Multicast Backbone
Router
Client
Router
Client
Router
Client
Router
Client
Client
Router
Client
Client

Figure 15

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US99/01104

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :H04Q 9/00; H04N 7/18; G06T 15/10
US CL :348/12,13,36,39
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 348/12, 13, 36, 38, 39, 42, 46; 395/125, 154; 364/514

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS: multicast, internet, virtual reality, and panoramic or panorama

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,495,576 A (RITCHEY) 02 February 1996, column 9, lines 30-57; column 10, lines 30-60; column 12, lines 20-68; column 18, lines 7-50; column 21, lines 27-68; column 22, lines 1-25.	1-42
Y	US 5,761,416 A (MANDAL et al) 02 June 1998, column 4, lines 20-65.	1-42
A, P	US 5,850,352 A (MOEZZI et al) 15 December 1998.	1-42
A	US 5,490,239 A (MYERS) 06 February 1996.	1-42
A	US 5,729,471 A (JAIN et al) 17 March 1998.	1-42

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search 26 MARCH 1999	Date of mailing of the international search report 15 JUN 1999
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer ANAND S. RAO Joni Hill Telephone No. (703) 305-4813